DEHYDRATION AND THE PRESERVATION OF FOODS

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THE possibility of partaking of strawberries and apples in regions of the earth remote from their native habitats and districts of production at first thought seems unlikely. Upon later reflection, however, the likelihood seems possible, since we realize that they may be canned, dried or even refrigerated. But the chance of being able to have them in a condition almost like that in which they would appear when gathered in fresh from the garden or orchard and placed on the table with little or no natural flavor removed, after transportation to either of these remote points, is a far different proposition. Yet I hope to show before the conclusion of this article that the ingenuity of man has made it quite possible to enjoy not only the full flavor and flesh of strawberries and apples in arctic or torrid climes, but in addition other fruits, vegetables and meats which are not produced in these regions.

The whole secret of being able to procure the kind of food you want where and when you want it is in its preservation. The reasons foods do not normally keep indefinitely are partly biological and partly chemical. The chemical agents responsible for food spoilage are called enzymes, the biological agents, microorganisms. All living cells of plants and animals normally contain enzymes that possess the power of changing substances insoluble in water into water-soluble substances without themselves suffering any change during their term of activity. These enzymes are produced by the living matter of the cell and remain active after the death of the cell. Some of them have the power of attacking carbohydrates such as starch or inulin, breaking these substances down into water-soluble sugars, others attack proteins such as albumens and globulins, splitting these up into water-soluble peptones, etc., still others attack fats breaking them down into water-soluble fatty acids and glycerin. Some of the enzymes are present in the cells of the food itself, others occur in the cells of microorganisms which attack food. All enzymes require a certain amount of warmth and the presence of water in order to get in their activity.

From the earliest period of the human race of which there are records man has striven to preserve foodstuffs available in season and region of abundance for use in times and places of scarcity. The ancients practiced sun drying of food on a large scale.

The following are the methods chiefly employed in the preservation of foods: (1) Drying, (2) Salting, (3) Pickling, (4) Smoking, (5) Refrigeration, (6) Canning, (7) Dehydration.

Drying of Food

The methods upon which foods are dried are based upon the principles that sufficient heat kills enzymes and the removal of water inhibits the growth of microorganisms, as well as prevents enzymic activity. In some instances, protective layers may be formed through drying by changing the former relationships of tissue constituents. Thus, for example, in the curing of pork, the fat, which is for the greater part isolated in distinct cells, becomes diffused throughout the outer layers of the flesh and forms a water-proof exterior to the ingress of microorganisms.

The removal of water in foods to an extent below the minimum required for the growth of microorganisms is secured in a number of ways. The most common ones are the uses of heat either in the form of sun's rays or from an artificial source. Sun drying is the oldest of these. In regions where the moisture content of the air is low, as in many of the fruit districts of California and other western states, exposure to the sun's rays accomplishes rapid drying. In this method insects and dust frequently have full access to the food. In more humid localities and with other types of food artificial heat is employed and so we have kiln drying and drying by means of centrifugal action. Kiln drying is much employed in the preparation of evaporated foods. In this method materials are laid on a screened floor under which heating appliances are built. The mass of material is stirred up occasionally during the drying. Drying by heat always results in concentrating the solutes. The acids in the juices of many fruits, when concentrated, may be antiseptic, *i. e.*, retard the growth of microorganisms. Frequently the sugars present reach so great a concentration as to plasmolyze the cell contents of any microorganisms present and so prevent their multiplication.

The disadvantages of all these methods of drying lies in the facts that they are slow, not all materials can be so treated and the products resulting do not regain their natural appearance, odor or taste when prepared for diet.

Salting

This is a method of preserving meats and fish. It has been

used for many centuries and next to drying is the oldest process known. It is dependent upon the principle that salt abstracts water from the tissues of the fleshy food and so causes a concentration of the solutes within the cells too great for the growth of bacteria. It gives the food a paler color and extracts at least 25 per cent. of the protein content. The great disadvantage in this method is the danger of undersalting or oversalting. Undersalted foods putrefy in time. Frequently the putrefaction is masked and ptomaine poisoning occurs after eating these. Oversalting destroys the natural flavor and extracts much of the nutritive substances.

Pickling

Pickling consists of the preservation of food in brine containing varying percentages of salt, vinegar, weak acids and occasionally condiments. Many foods such as olives, cucumbers, cauliflower, beets, and some meats and fish, are preserved by this method. That pickling is not always a safe method of food perservation has recently been emphasized by many outbreaks of botulism poisoning from pickled ripe olives.

Smoking

This is a method of preserving flesh foods and flesh derivaties such as meat and fish. It consists of first placing the fleshy food in brine with or without condiments for a week or longer. A smouldering fire is then built in a specially constructed chamber. The flesh foods are taken out of the brine and hung up, being exposed for varying periods of time to the wood smoke and heat. The volatile substances in the wood smoke such as creosote, acetic acid and other germicidal substances penetrate the food at least superficially and either kill any putrefactive organisms present or retard their growth.

Refrigeration

Refrigeration is a method of preserving foods which is based upon the principle that cold inhibits the activity of microorganisms. During the past two decades it has revolutionized the meat and eggs industries. In the meat industry it permits slaughtering to take place all the year round and great cargoes to be transported in refrigerating chambers across oceans and continents and through equatorial regions not much the worse for the transporting.

Foods preserved by refrigeration generally command a higher price than those preserved by other methods. This is in part due to the fact that the general appearance of cold storage food resembles that of the perfectly fresh article. In numerous instances, also, refrigeration, for a reasonable length of time, preserves not

only the appearance but also the delicate flavor, chemical composition and nutritive value of the original articles.

During the storage of food it undergoes some loss of water and volatile principles by evaporation and various volatile principles may be absorbed from the air of the storage room. But by far the most important point to be considered in this connection is the behavior of the biologic content of the food during this period. It should be emphasized here that refrigeration not only impedes the growth of microorganisms, but tends to preserve them as well. In addition to the organisms present in the food when it is stored, other microbes such as bacteria, yeasts and molds, may gain access to the food from time to time either by actual contact with other things or through the circulating air within the cold storage chamber.

As to whether these implanted forms will survive depends upon their nature and ability to adapt themselves to the conditions existing within the stored food. Some perish, others may survive in the passive condition, still others may survive in their active form, multiplying rapidly. It has been known for some time that some bacteria can grow at a temperature of zero and that many can reproduce at a fraction of a degree above that point. If microbic activity is, therefore, to be inhibited, the food must be frozen.

Methods of refrigeration vary depending upon the article to be refrigerated. In the production of chilled meats, the flesh of mammals is first placed in a cold chamber at a temperature of about $+2^{\circ}$ for the first 48 hours and then stored at a temperature of $+1^{\circ}$ or $+2^{\circ}$ if chilled meat is desired. During the chilling process the enzymes of the dead flesh and bacteria present are active, bringing about a ripening or curing, which makes the meat more tender and gives it a more desirable flavor. If the chilling process be allowed to proceed beyond the point where the muscle sugar is nearly completely fermented, the changes in the meat due to the decomposition of proteid material by bacterial enzymes makes it dangerous and unfit for consumption.

In the preparation of frozen meat, the dressed article is chilled in an air-chamber at -20° until it is frozen solid and later kept at a temperature below -4°. Such meat remains practically unchanged for long periods. The difficulty arises when it is thawed. If warmed slowly the melting water crystals are absorbed by the protein material and the original structure of the flesh restored almost completely, but bacteria are always bound to enter in a prolonged process of this kind and cause some decomposition. In order to prevent this, the thawing is usually carried on rapidly and so the normal structure of the meat is not restored. It is

softer, darker and moister than chilled or fresh meat and prone to rapid decomposition if kept at room temperature for even short periods.

In the refrigeration of fish and poultry, these articles are chilled by packing in ice immediately after death and frozen as rapidly as possible. In thawing similar changes take place as in frozen meat but the bacterial decomposition proceeds more energetically. After thawing is complete the products spoil rapidly.

Eggs should be stored at a constant temperature which should be between +0.5° and +1° and at a constant humidity of 70 per cent saturation, if superior results are to be attained. But even with the best of control and precautions there is some deterioration in the cold storage article due to the facts that the enzymes within the egg are not necessarily inhibited nor is the growth of all of the bacteria prevented.

Milk is more rapidly changed by bacterial activity than any other food. In up to date dairies it is therefore cooled immediately after it is drawn from the animal and kept at a low temperature until delivered to the consumer. But even at this low temperature the milk bacteria multiply slowly. Freezing alone prevents their multiplication. If the milk is very clean, however, it may be kept sweet for several weeks at a temperature slightly above the freezing point.

Fruits and vegetables are refrigerated at a temperature slightly above zero and at a constant humidity of about 60 per cent. saturation. In spite of modern methods of refrigeration it is not practicable to ship fresh sea foods to distant inland towns or to send some perishable fruits and vegetables of the tropics to colder climes.

Canning

Canning is a method of food preservation the principles of which include the destruction of microorganisms which produce the fermentative and putrefactive changes by heat and subsequently sealing the container to prevent the access of more microorganisms.

The principle of employing heat in the preservation of food had its origin in the experiments of Spallanzani, who in 1765 boiled meat extract in flasks for an hour and hermetically sealed them, after which no change took place in the material. Spallanzani, however, was not aware of the real cause of these changes.

About the middle of the nineteenth century, Tyndall and Pasteur successfully demonstrated that living microorganisms were always found where fermentation and putrefaction took place, that these organisms could be killed by heat and that if substances

liable to decomposition which had been sterilized by heat were kept so that no organisms could gain entrance, they would keep indefinitely without spoiling. But long before the causes of fermentation and putrefaction were known canning was discovered.

During the Napoleonic wars the French government faced the problem of maintaining an adequate supply of food for their army and navy and offered a prize of 12,000 francs to the person who could invent the best method of preserving food. Stimulated by this offer, Nicholas Appert, a Parisian confectioner, undertook the task. After several years of ardent investigation he discovered a method which he submitted to the Minister of the Interior. A number of substances which Appert had preserved including meat, vegetables, fruits, milk and soup were examined by the Bureau Consultif, a commission appointed by the minister, which included such men as Gay Lussac, Bardel, Scipion-Perrier and Molard.

This body reported that when the jars were opened after several months, the foods were found to be perfectly preserved and in every way satisfactory in flavor and appearance. On the strength of this report, Appert was awarded the prize of 12,000 francs. It was not until the following year (1810) that Appert published his discovery under the title of "L' Art de Conserver pendant plusiers toules les substances animal et vegetables" ("The Art of Preserving Animal and Vegetable Substances.")

Appert's method consisted of enclosing food in glass jars which were then corked tightly, placed in a bath of boiling water the time varying according to the article treated and taking the jars from the bath at the prescribed time and in a proper manner. Appert later used tin cans as containers. The success of his method was dependent upon sterilization and the absolute exclusion of air. These same principles are applied in the canning of to-day.

From France the canning method was introduced into England by Peter Durand, who in 1810 obtained a patent from the English government for the preservation of a variety of food in hermetically sealed tin cans and glass jars. Among the first to introduce the process into the United States were Ezra Dagget and Thomas Kensett, who in 1819 began to manufacture canned oysters, lobsters and salmon. In 1820 William Underwood and Charles Mitchell opened a canning factory in Boston, where they packed currants, plums, quinces and cranberries.

Enormous losses were experienced during the early years of the canning industry due to the defective nature of the square tin cans. The square can finally gave way to the economically superior round can. A press for manufacturing can tops was invented in 1850.

In 1883 a hand capping machine was patented and later various other kinds of machinery replaced hand labor.

The Civil War did more to stimulate the canning industry in America than any other factor. To-day it is recognized as the main method of preserving foods in this country and likewise the most popular.

Disadvantages of Canned Foods

It is a well-known fact amongst chemists and physicians of to-day that the heat necessary to bring about the successful sterilization of milk, fruits, vegetables and meat destroys vitamines. These vitamines are regarded as absolutely essential for the growth, development and protection of the body against certain diseases such as scurvy and beri-beri.

In writing on the vitamines, Colonel Vedder, M. C., U. S. A., states: "It should also be noted that all canned foods must be regarded as possible beri-beri producers. It has been shown by numerous investigators, including the writer, that heating to 120°C. destroys the beri-beri preventing vitamines in certain foods. All protein foods that are 'canned' must be subjected to about this amount of heat in order to kill all the putrefactive organisms and such canned foods are, undoubtedly, beri-beri producers when used in excess."

I have recently been informed by Mr. P. R. Buettner of Danbury, Connecticut, that canned tomatoes retain some of their natural vitamines due to the protective power of the acid in this fruit during processing.

The second disadvantage of using canned goods is in their great cost of production. From four to seven ounces of tin plate are used for each container. To this must be added the cost of packing cases and the handling, canning and transportation of much water. A third disadvantage is the fact that they have limited keeping qualities. There is always danger of crushing and spoilage in transporting them. Moreover, most of those products, when prepared for the table do not possess the same appearance, odor and taste as those of the freshly prepared articles from the field or garden.

Dehydration

Dehydration in the modern sense of the term may be defined as the process whereby perishable foods with or without previous treatment are subjected to the action of carefully regulated currents of air in which the temperature and humidity are properly controlled.

The method results in the food products gradually losing water,

but without giving up their color or flavor or having their cellular structure impaired. Accordingly, the dehydrated food will reabsorb water, swelling up to its normal size and appearance. When cooked it will have the same appearance, flavor and odor of freshly cooked material made from fresh vegetables.

Dehydration dates back to 1850, when Masson, a Frenchman, dried a large number of vegetables and fruits with a blast of warm air at temperature near 70° C. Sometime later, Passburg of Berlin obtained excellent results with vacuum drying apparatus. It was not, however, until the Boer War that products of this nature began to be manufactured on a considerable scale. During this period many thousands of pounds of dried vegetables, mixed so as to form a basis for an easily prepared soup, were produced in Canada and shipped from there to the British Army in South Africa.

Stimulated by the possibilities of marketing products of this nature on a commercial scale, a number of Americans established factories in this country and by 1910 began to manufacture dehydrated vegetables and soup mixtures. These products, however, never became popular, partly because they were not quite equal to the fresh article when cooked and partly because of the great popular demand for canned foods.

War is without doubt a great stimulator of human ingenuity, no less in perfecting methods than in inventing new ones. Just as the Civil War stimulated the introduction of new methods in the canning industry, so the World War established new methods and perfected older ones in the dehydration industry. With the problems of supplying our armies in distant fields and our ships in foreign seas with a variety of foods, and the limit of our tonnage, the food situation became acute. More and more demands were made by the government for dehydrated products in order to save transportation of water and to provide our fighters with fruits and vegetables that could not be obtained in England and France. Thousands of tons of these foods were shipped abroad during the war to the forces of the United States as well as the Allies.

It was the dehydration process that probably enabled Germany to maintain her food supplies during the war. That it was successful in that country can not be doubted when we consider the following statistics: In 1898 there were only three small dehydration plants in Germany. Eight years later the number in operation was thirty-nine, in 1914 it had increased to 488, in 1916 to 841 and in 1917 to about 1,900. By August 1st of this year there were 29 concerns manufacturing dehydrated fruits and vegetables

in the United States. To this may be added at least a dozen firms who manufacture dehydrated animal products.

The methods of dehydration employed at the present time are varied in details of procedure. All, however, are founded on the same basic principle, namely, to remove the water contained in and between the cells of the food so as to obtain a product which can not spoil as a result of microbic or enzyme action.

The water taken away by these methods is only replaceable water and so the nutritional value of the food has not been altered. Moreover, if dehydration is applied while the fruits, vegetables or animal products are absolutely fresh, the flavor-giving substances are preserved intact. In the best grades of dehydrated products the rate of evaporation is such as to bring about the removal of water without rupture to the cell walls.

By means of this process the weight of the food is reduced from 80 to 90 per cent. and the bulk is diminished to one fourth or one sixth of the original volume. By means of compression the nearly dried material may be brought to a compact form as, for example, in the Veco products. Not all the water is removed, the amount remaining varying depending upon the character of the food to from 7 to 15 per cent. But sufficient is removed to concentrate the solutes to the extent of producing plasmolysis.

The manner in which the material is prepared influences to some extent the quality of the product. If the first temperature applied to the fresh material is too high, certain changes take place in many vegetables giving them an appearance of scorched or scalded substances and diminishing their water-absorbing power. Accordingly, in dehydrating vegetables, the fresh material should be subjected to air having a low temperature and high humidity and gradually brought to a high temperature and low humidity.

Methods of Dehydration

The methods of dehydration employed at the present time are as follows:

(1). Tunnel Systems. These consist of long chambers or tunnels into the end of which the fruits or vegetables are introduced on screens or racks and through which a strong current of dry air is blown. While there are several modifications in the arrangement of the screens and in the method of heating and driving the air, it may be said that in general the heat is supplied by coils of steam pipe and the air is forced in by powerful fans. In some plants the racks of vegetables are placed on trucks which run on tracks, so that the material is introduced at one end of the tunnel where the temperature is low and humidity relatively high, grad-

ually moved on to where the temperature is higher and the humidity relatively lower and delivered at the other end in dry form. By this means the moisture is uniformly extracted by capillary attraction without destroying the cell structure. On account of the gradual reduction of the moisture content, the cells shrink slowly without breaking down and the product retains all of its natural flavor, color and food value. In other plants the tunnels have side openings where the trays are inserted and removed by hand.

In the Hammond tunnel system, the patents of which are owned and controlled by the Unted States Dehydration Company of Denver, Colorado, the prepared fruits, vegetables or animal foods are placed in a rectangular tunnel and gradually conveyed through it, the moisture, temperature and rate of air flow all being properly coordinated. The air is allowed to take its course straight through, passing over the top of the trays or underneath them. Most of the products are steam blanched or dipped in hot water before being introduced into the drier which operation has been found quite necessary in preserving the color and keeping qualities of vegetables.

The Cook-Kelly process employed in the manufacture of "Cookelized foods" is another of these tunnel systems. In preparing foods by this process, fruits and vegetables are brought into the factory and washed, peeled, pared, sliced, cubed or riced, put on wire screen trays and placed in a rectangular tunnel approximately 35 feet long. Heated air is blown through this tunnel, the currents of this air taking the form of a sine curve as they go upward through one tray and downward through the next and so on. The trays are shoved along periodically which causes the air to reverse its passage through the products on the tray from time to time, evaporating the moisture from the products and carrying the moisture off through the other end of the tunnel.

(2). Vacuum Methods. These have been employed with success in the dehydration of fruits, vegetables and animal products. The apparatus consists of a heavy cast iron chamber containing a large number of steel shelves heated either by steam, hot water or electricity, a condenser and a vacuum pump to exhaust the air from the chamber and maintain a high vacuum on the system. The material to be dried is placed on flat screens which slide into the shelves. Heating is partly by conduction from the metal trays and partly by radiation from the next shelf above. The temperature is regulated by a thermostat, so that overheating is impossible. Through the constant application of a vacuum to the process, the water vapor is removed and the material dehydrated.

This method is particularly advantageous for the dehydration

of potatoes and apples or other vegetables containing an oxidase ferment. It is this ferment which causes the darkening of such materials when their flesh is exposed to the air. Since air is removed from the chamber no darkening results by this process. However, if such vegetables are subsequently placed in water, darkening will result, since the ferment has not been entirely destroyed. This is overcome by blanching or steam treatment before the foods are dehydrated. In the dehydration of milk and eggs by the vacuum method, heated rollers are employed. These, with various attachments, are enclosed in a chamber in which a high vacuum is maintained. The heated roller picks up a film of egg pulp or milk which dries rapidly under reduced pressure and is continuously scraped off by a knife as dried flakes or powder. In the dehydration of meats, this method is probably unequalled by any other one in its effectiveness. Large steaks and chops can be handled without oxidation and completely dried. The fats remain white and are not melted. The product is essentially raw meat with water removed. Usually a temperature of 130° F. is employed. Fish, lobster, meat, clams, oysters, shrimps and other protein foods that ordinarily putrefy easily can be preserved in excellent form by this method. Since these products are dried to about 30 to 35 per cent. of their original weight, the concentration of the solutes is too great to permit bacterial development. Most fruits and vegetables require higher temperatures than those to which flesh foods are subjected when dried by this method. With some of the products this method gives good results but is rather severe with others, tending to break down their cellular structure.

(3). Kiln Method. In this method of dehydration, square chambers with sloping roofs and perforated floors are utilized. The floor is heated from below by a stove or furnace. The materials to be dehydrated are spread on the floor to a depth of four or six inches. The hot air from the heating device passes up through the vegetables, removing the moisture, which is conducted through a ventilator in the roof. The mass of vegetables is turned over now and then by men with shovels during the drying. The advantage of this method is mainly its cheapness. The disadvantages are those of overheating or underheating. However, a number of products made thereby have proven satisfactory.

(4). Special Dehydrators. A number of special types of chambers or machines are now in use, differing from those previously considered only in certain details of construction. Many of these have appliances to carefully regulate the drying.

Keeping Qualities of Dehydrated Foods

That dehydrated foods will keep for a long time, if properly

prepared, is evidenced by the following occurrence: During the Boer War the British Army in South Africa was supplied with thousands of pounds of dehydrated vegetables mixed so as to form the basis of a quickly prepared soup. At the close of the war one of the Canadian manufacturers was left with 30,000 pounds of this mixture for which he could not find a market, probably due to the fact that consumers much preferred to buy such vegetables in the recent condition. He placed it in barrels which were paraffined and stored it away. Fifteen years later, after the outbreak of the world war, these were shipped to the British Army in Europe and used in the preparation of soups of splendid quality. If dehydrated foods are properly prepared and kept in paraffined containers free from insect pests and ingress of moisture, there seems to be no reason why they should not keep for indefinitely long periods.

Advantages of Dehydrated Foods Over Other Preserved Products

Dehydrated foods are superior to dried or evaporated articles because they regain the natural appearance and keep the natural odor and taste of the fresh articles when prepared for the table. Moreover, they have better keeping qualities.

Their advantages over refrigerated articles lies in the saving of cold storage charges, in the lessened transportation charges and in their superior keeping qualities. Their advantages over canned foods lie in the great saving in freight charges (since the water content is reduced to 5 or 10 per cent.), in their freedom from spoilage, their greater ease of handling, their superior keeping qualities, and in the cheap containers that may be used. Moreover, there is no danger of botulism, nor are any of the vitamines destroyed. Dehydrated foods can be shipped to any part of the globe without deterioration.

Possibility of Dehydration in the United States

While much has been accomplished in the field of dehydration in the United States since the beginning of the world war, the surface has only been scratched. A goodly number of vegetables, fruits and a few animal products are being dehydrated successfully while scores of others have not as yet been taken up. Each kind of vegetable or animal food must be studied separately in order to properly perfect its best means of drying by this method. Dehydration is destined to stabilize the crops of the nation. Year after year, decade after decade, we are confronted by either feast or famine in respect to certain fruits or vegetables.

A good crop one year with correspondingly low prices has often been followed by a small crop the following year with high prices.

With an extension of this industry the surplus of years of great yield can be stored and made available in later years when prices are higher and the crop leaner. In a short time the amount of planting would be equalized and all would be able to secure an adequate supply of these foods at normal prices.

Again, dehydration is destined to conserve food materials. It is a notorious fact that about half of the perishable fruits and vegetables grown in this country is wasted annually on the farm, at the freight station, in transit or in the hands of the commission merchant both as a result of poor transportation facilities and irregularities in marketing.

According to the *Los Angeles Examiner,* "only 40 per cent. of the California products contributed to relieve the famine sufferers in China ever reached them in edible condition." "Had the wasted 60 per cent. been dehydrated, it would not have failed of its merciful purpose."

Again, on account of the strict grading laws enforced by the Potato Growers' Association, it is estimated that about 50,000 bushels of No. 2 undersized, sound potatoes are annually lost to farmers. The potato dehydrating industry is comparatively recent in America and dehydrated potato flour is being manufactured from some of the previously wasted material. With the spread and development of this and other allied industries much of what had previously been wasted will be conserved for the benefit of the people. The dehydration of the sugar beet and the banana offer wonderful possibilities in this direction.

It is conceivable that dehydration, now in its infancy, will within the next decade, when the nature of its products become more generally known, rival, if not outstrip, the other processes of preserving foods.